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**Surveys of Procellariiform Seabirds at
Hawai`i Volcanoes National Park, 2001 - 2005**

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ABSTRACT

This report combines data for procellariiform seabird colony searches conducted in 2005, sporadic surveys for procellariiformes between 2001 and 2005, as well as seabird radar surveys conducted in 2002 at Hawai'i Volcanoes National Park. The objectives of these surveys were to inventory procellariiform species diversity and identify seabird flight corridors and breeding seabird colony sites within park boundaries. Specifically, goals were to locate nesting colonies of Newell's Shearwater (*Puffinus auricularis newelli*) which is listed as threatened by the US Fish and Wildlife Service and Band-rumped Storm-Petrel (*Oceanodroma castro*), a candidate species for listing. Radar surveys were intended to provide information to assist in targeted foot searches for seabird colonies. Reports and results of radar surveys are summarized, but no new radar surveys were conducted in 2005. We performed nighttime and daytime auditory and visual surveys at a variety of locations and a range of elevations within Hawai'i Volcanoes National Park to document Newell's Shearwater and Band-rumped Storm-Petrel activity. Data from nighttime auditory surveys and incidental reports collected in previous years are also summarized. Seabirds recorded at high elevations included Hawaiian Petrels (*Pterodroma sandwichensis*), federally listed as endangered, and Band-rumped Storm. We identified one possible Band-rumped Storm-Petrel nest location, but only continued monitoring will confirm nesting. We did not detect any Newell's Shearwaters at mid-elevation sites. However, based on incidental reports of Newell's Shearwaters calling repeatedly near the trailhead of the Kalapana trail, the rain forest remaining in the East Rift Zone is likely to be the one location at which this species continues to nest at Hawai'i Volcanoes National Park. We also documented Newell's Shearwaters at a coastal location, but the birds were most likely prospecting for or transitting to nesting sites.

INTRODUCTION

Seabirds in Hawai'i have suffered drastic declines in numbers as a result of human influence, both historically and prehistorically. The entire avifauna of Hawai'i was much more varied and numerous before the arrival of humans to the Hawaiian Islands (Olson and James 1982a). Endemic avifauna of Hawai'i suffered significant prehistoric extinctions and depletions due to habitat modification and predation by Polynesians and the mammals they brought to Hawai'i (Olson and James 1982a; Athens et al. 1991). Several species of ground nesting seabirds were eaten by Hawaiians (Athens et al. 1991) but burrowing seabirds would have also been vulnerable to predation by the dogs (*Canis familiaris*), rats (*Rattus exulans*), and pigs (*Sus scrofa*), that arrived in Hawai'i with Polynesians (Olson and James 1982b). Though predation contributed to the decline of seabirds, destruction of nesting habitat through clearing of land for Hawaiian agriculture may have also been an important factor (Olson and James 1982b; Cuddihy and Stone 1990). On Hawai'i Island, once-significant breeding populations of Hawaiian Petrels (*Pterodroma sandwichensis*, HAPE) remained in only very small numbers by the end of the 20th century (Richardson 1954; Banko 1980b; Conant 1980). Abundant Newell's Shearwater (*Puffinus auricularis newelli*, NESH) breeding colonies once known historically from Hawai'i, Maui, Molokai and Kaua'i (Banko 1980) remained only on Kaua'i (Banko 1980) but small populations apparently persisted on other islands including Hawai'i (Ainley et al. 1997; Conant 1980; Reynolds and Ritchotte 1997). No nests of Band-rumped Storm-petrels (*Oceanodroma castro*, BSTP) have been found on Hawai'i Island, but breeding colonies are suspected in remote locations inaccessible to predators (Slotterback 2002; NPS unpublished data). Harvesting seabirds for human consumption is no longer a factor in their decline, but the downward population trend continues due to modern threats such as habitat destruction, habitat fragmentation, avian disease, climate change and predation by introduced mammals (Hodges, 1994; Hodges and Nagata, 2001; Hu et al., 2001) and by owls (Ainley 1997). In addition, attraction to bright lights may lure fledglings off course, causing them to be stunned and fall prey to predators, or to collide with buildings, wires, tall vegetation, and vehicles (Reed et al. 1985; Telfer et al. 1987; Simons and Hodges 1998).

Previous bird surveys have been conducted at HAVO (Banko and Banko 1979; Conant 1980a, 1981; Hu et al. 2001), but none have systematically surveyed procellariiform seabirds throughout the park. Repeated auditory and visual detections of BSTP, a candidate for listing under the Endangered Species Act, in subalpine areas of HAVO suggests that they do nest on Mauna Loa (HAVO Resources Management unpubl. data). Potential also exists that remnant colonies of the threatened NESH occur in mid-elevation rain forests (700-1000 m elevation) in the East Rift Zone of Kīlauea. Any colonies remaining are in dire need of protection and active management.

Hawaiian Petrels, listed as endangered by the US Fish and Wildlife Service (USFWS), are the most consistently monitored seabird species at HAVO. This species was thought extirpated from Hawai'i Island until rediscovered on Mauna Kea in 1954 (Richardson and Woodside 1954) and on Mauna Loa in 1980 (Conant 1980b). Seabird surveys at HAVO have focused on HAPE in subalpine areas between 1,825 m and 3,050 m elevation. Attempts by the HAVO Resources Management (RM) division to survey for and monitor HAPE nests began in 1992, continued through 1997, and were reinitiated in late 2000. Regular monitoring of HAPE and sporadic predator control continue at known colonies.

Band-rumped Storm-Petrels are considered the rarest breeding seabird in Hawai'i (Banko et al. 1991; Slotterback 2002). Though no colonies or nests have been found, there is ample evidence that they breed on Hawai'i Island. Banko et al. (1991) identified three BSTP carcasses collected from Hawai'i Island from 1949 and later documented BSTP calling on Mauna Loa. One of the carcasses was found along the Southwest Rift Zone of Mauna Loa, an area now inside the recently added Kahuku portion of HAVO. Further evidence of BSTP nesting on Mauna Loa includes two carcasses of this species found at 2,600 m in 1994, a carcass collected at 2,440 m in 2003, one BSTP caught in mist nets at 2,600 m in 2003, and one adult found dead under power lines on the Mauna Loa Observatory Road in 2003 (HAVO RM unpubl. data). In addition, BSTP vocalizations are heard regularly at high elevations on Mauna Loa. This evidence suggests that BSTP still breed on Mauna Loa, possibly in close proximity to HAPE. The intent of this inventory was to locate BSTP colonies in preparation for protective management.

Few records documenting NESH colonies within HAVO exist. Evidence from 1972 of a small breeding colony at Makaopuhi Crater included a carcass and bird calls in the area (Banko 1980). Banko (1980) also reported NESH in the vicinity of the park offshore of Kalapana in 1970 and 1975. More recently, Reynolds and Ritchotte (1997) found evidence of NESH nesting in forested pit craters in the Puna district adjacent to HAVO. These observations led us to believe that NESH may still nest in HAVO.

Wedge-tailed Shearwaters (*Puffinus pacificus*, WTSH) are common on most of the remote Northwestern Hawaiian Islands and still breed on some of the main Hawaiian Islands and associated offshore islets (Harrison 1990; Whittow 1997). This species is not known to regularly occur within Hawai'i Volcanoes National Park, but recent nest burrows found at Kaloko-Honokōhau National Historical Park indicate that WTSH still attempt to nest on some parts of Hawaii Island (D. Hu, NPS, pers. comm.)

This procellariiform seabird inventory at HAVO was carried out to provide preliminary data for these nocturnal seabirds. More specifically, the objectives of these surveys were to document diversity of procellariiform seabirds and identify seabird flight corridors as well as breeding seabird colony sites at HAVO. This report includes results of radar surveys conducted in 2002 as well as a short review of three published radar studies (1994-2002). Also included are results of targeted ground searches and auditory and nightvision surveys conducted in 2005, as well as sporadic surveys and incidental observations by HAVO crews for the years 2001 to 2005.

METHODS

We did not conduct new radar surveys for this inventory, but summarized results of radar surveys carried out by HAVO RM in 2002, and reviewed three published studies of radar surveys conducted in 1994, 2001-2002, and 2004, to provide information about potential locations of colonies of burrow-nesting seabirds in densely forested, rugged terrain in HAVO. In 2005 we conducted focused searches for seabird colonies based on these previous radar surveys and a host of unpublished data collected between 2001 and 2005 by HAVO RM.

Seabird Radar Surveys

Reynolds et al. (1997) conducted radar surveys at three sites in HAVO: Mauna Loa, Kealakomo, and Pali Uli in 1994. Radar was also used in 2001 and 2002 to survey seabirds at Hōlei Sea Arch (Day et al. 2003) and in 2004 adjacent to the Kīlauea Visitor Center (Day et al. 2004). The three reports describe detailed methodology and generally followed the protocols by Cooper et al. (1991).

In addition, radar surveys were conducted by HAVO RM staff at 2,650 m on the southeastern flank of Mauna Loa in 2002. On 10 and 12 September 2002, radar surveys were conducted at this site for three hours per night from 19:00 to 22:00 h. Observers collected information on flight frequency and patterns using a Furuno 1510 MKIII marine radar unit to survey a 1.5 km radius. The plotting function was set to “continuous” to present a series of successive echoes on the display screen. This marine radar unit, owned by the US Fish and Wildlife Service, was transported to the remote site by helicopter. A six-foot tall wooden platform supported the unit at the top of a steep lava slope. While one observer monitored the radar screen from inside a tent adjacent to the radar antenna, a second observer sat outside, attempting to sight targets using night vision goggles (Model ATN PVS7; Ranger Joe’s International, Columbus, GA). Radar survey techniques followed Cooper et al. (1991). Data were collected within 25-minute sampling sessions, followed by five-minute breaks. For each target, observers recorded speed, distance from observer to target, and direction of flight. The speed of the targets was judged by the spacing of echoes recorded in successive sweeps of the radar. Only targets flying 48 km/h or faster were considered seabirds (Day and Cooper 1995). Observers considered all targets identified as seabirds to be HAPE or BSTP because NESH have not been heard at these high elevations in HAVO (D. Hu, NPS, pers. comm.). Statistical analyses were not conducted on these data because of the small sample size (19 targets). However, the data yielded preliminary information about the frequency and general flight patterns of birds observed.

Procellariiform Colony Searches

Surveys for this study were conducted from 27 June through 24 August 2005; additional data from previous HAVO RM monitoring activities (2001-2005) are summarized as well. For all surveys, the search season was chosen based on breeding chronologies reported in species accounts for NESH (Ainley et al. 1997) and BSTP (Slotterback 2002).

Study Areas

We selected survey locations based on previous NESH and BSTP occurrence or similarity with breeding habitat elsewhere. Only sites judged as suitable nesting habitat were revisited for night surveys after initial daytime reconnaissance.

Due to pressure from predators, preferred nesting habitat of Newell's Shearwaters is on steep slopes, generally in open canopy forest with an uluhe fern (*Dicranopteris linearis*) understory, but nests have also been found on bare slopes (Ainley et. al 1997). In the Puna District of Hawaii, adjacent to HAVO, colonies were detected between 189 and 330 m elevation (Reynolds and Ritchotte 1997). We visited two forested pit craters, Makaopuhi and Nāpau, in the East Rift Zone, based upon recommendations that these types of areas would be the most likely places in HAVO to find NESH (M. Reynolds, USGS, pers. comm.). We also surveyed mid-elevation forested pit craters at Kahuku and along Chain of Craters Road. One site at the junction of the Kalapana trail and the Nāulu trail was surveyed because of reports of NESH calling in the vicinity. Selected coastal sites surveyed for nocturnal seabirds included Ka'aha, 'Āpua Point, and Halapē. Nāpu'uonā'elemākule (located where the Ka'aha trail meets the coast) and Kālu'e (a beach approximately one mile south from Ka'aha shelter) were also searched during the day but no nighttime auditory surveys were conducted at these two sites.

We chose mostly high elevation sites above 1,830 m for BSTP surveys based upon previous detections in subalpine habitats (HAVO RM unpubl. data). These included three sites at approximately 2,350 m, 2,550 m, and 2,700 m on the southeast flank of Mauna Loa and the Southwest Rift Zone of Kahuku. One group of nighttime observation sites near the border of Kahuku above Hawaiian Ocean View Estates is at a slightly lower elevation between 1,450 m and 1,650 m. An overview map of Hawai'i Volcanoes National Park is shown in Figure 1.

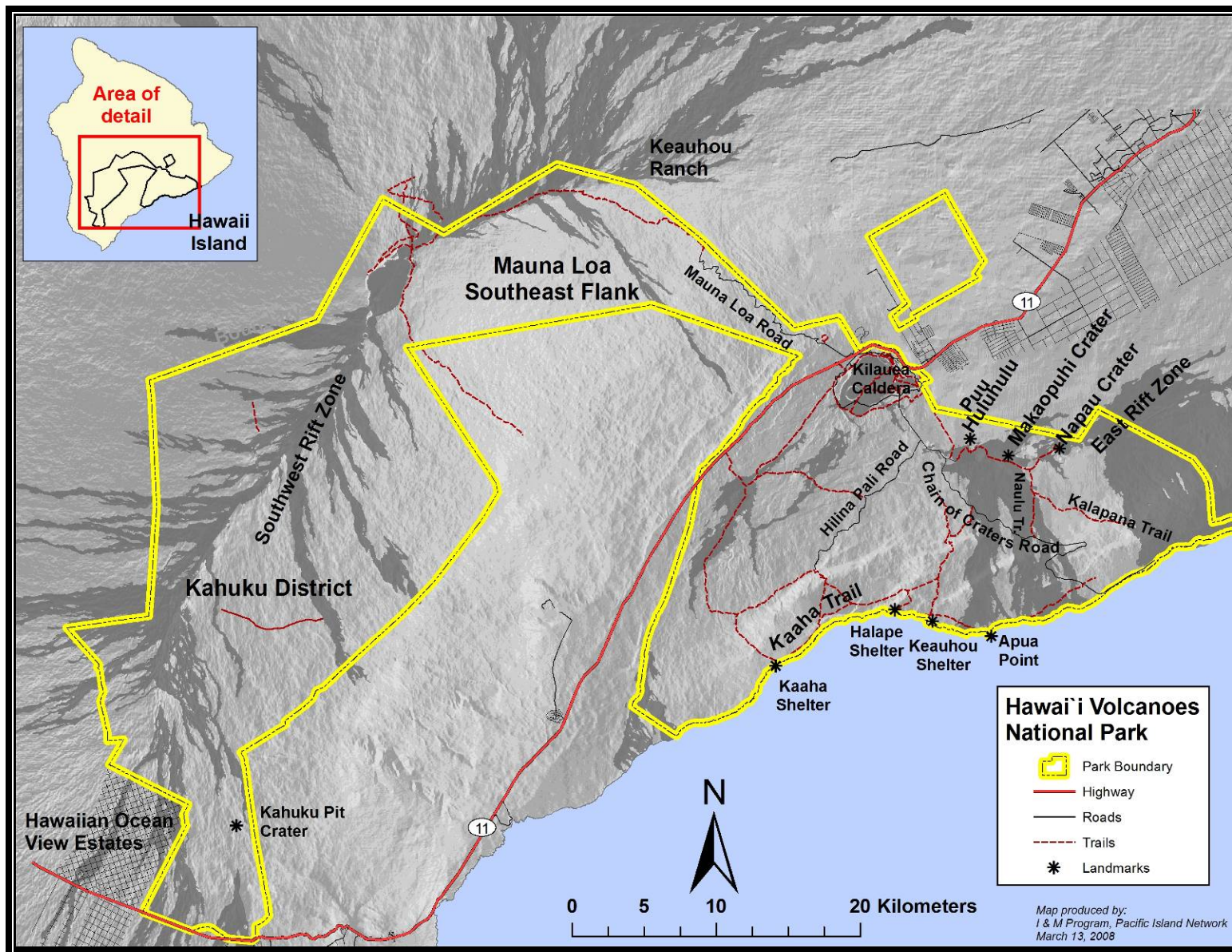


Figure 1. Map of Hawai'i Volcanoes National Park

Field Methods

2005 surveys

Surveys were conducted during July and August 2005 when colony visitation by both breeding and non-breeding adults was expected to be at its peak. Surveys included daytime ground searches and nighttime auditory surveys.

Surveys for NESH were conducted at elevations less than 2,400 m. Ground searches for NESH involved visits to pit craters to look for appropriate burrowing habitat. At pit craters where searches on foot were not possible because of near-vertical terrain, we scanned crater walls with binoculars (Leica, 8x32). We included habitat descriptions for each location along with notes regarding indications of nesting activity. We attempted ground searches in the rain forest of the East Rift Zone on foot, but abandoned the effort because of lack of progress through the thick uluhe fern understory.

Ground searches for BSTP were conducted on foot along high elevation (>2,400 m) lava flows and cinder cones, based on previous detections of this species in such habitat. Surveyors looked for evidence of breeding activity such as guano, feathers, natal down, and footprints. Areas searched (regardless of presence or absence of birds) and any breeding colonies or roosts were mapped with a Garmin 12 CX GPS unit. Datum utilized was Universal Transverse Mercator, North American Datum 1983, 5Q. We also deployed a TrailMaster® active infrared event recorder and camera at one nest in an attempt to document suspected occupation by a BSTP.

Nighttime auditory surveys followed daytime visits to potential breeding sites. Auditory surveys were conducted during evening (20:00 to 22:00) hours when detections were most likely (Sincock *in* Conant 1980b; Reynolds and Ritchotte 1997). However, some surveys for NESH extended throughout the night to maximize chances of detecting this rare species during limited survey nights. Surveys were mainly auditory with observers attempting to distinguish between two main types of call: the 'Ua`u call associated with HAPE display activity and a "ti-ti" call used by commuting birds of unknown species, possibly BSTP. Observers also recorded aural detections of wing noise made by birds flying silently overhead. Visual detections were assisted with night vision goggles and binoculars. We played recorded calls of NESH in an attempt to illicit responses from passing seabirds. We did not broadcast recorded calls of HAPE and BSTP because we did not want to disrupt breeding activities of birds heard calling in the areas surveyed.

Vocalizations often vary between BSTP individuals (personal observation); observers attempted to judge whether consecutive calls were from distinct individuals or repeated calls by one bird. For each pass, observers recorded the time, the number of birds, whether the detection was visual or aural, the type of flight (straight or circling), the approximate flight height, whether the bird was silent or vocalizing, the type of vocalization ('Ua`u call or ti-ti call), the tonal quality of vocalization (high and clear or low and raspy), approximate distance from observer at the closest point, approximate bearing from observer, and the overall direction of travel of each bird.

Previous surveys within the park

Results presented in this report include data from surveys conducted between 2001 and 2005, all during the months of July to September, by HAVO RM staff. Methods were essentially the same as described above. The exception was that during two survey nights in 2001 and one survey night in 2005 at the Southeast 1 and Southeast 2 sites, multiple bearings and multiple distances were recorded for each passing bird. This difference in methods did not change counts derived from auditory surveys but did affect the methods for the mapping of flightlines. No recorded bird calls were played during these surveys.

Previous surveys outside the park

Nighttime auditory surveys were conducted in 2004 on Kamehameha Schools land along the proposed fence alignment between Kūlanī prison and the national park's Keauhou boundary. These surveys, organized by the 'Ōla'a-Kīlauea partnership, were conducted to assess montane seabird occurrence along the proposed fenceline corridor. Survey teams of two persons each were dropped off at intervals along the upper segment of the fence line above 2,300 m elevation. Observers spent three nights (July 6–8) listening for petrel calls at each survey site, though surveys on the third night were limited by inclement weather. Survey methods followed the descriptions above, but no recorded bird calls were played.

Determination of Flightlines

Data from nighttime auditory surveys were mapped in an attempt to view flyways, which may help locate nesting colonies in the future. We did not map birds that appeared to be circling because we were trying to identify flyways of birds traveling directly to and from colonies. Depending on the type of data collected during nighttime auditory surveys, two different methods were used for mapping. In the first method we mapped data in which an observer had recorded distances and bearings to multiple calls of a bird traveling up- or downslope (as mentioned above, this type of data was collected in only a few surveys by HAVO RM). That is, if a bird flying by emitted four calls, the observer noted the estimated distance and bearing to the observer for each call. Thus, each call of the bird represented a point which was independently mapped. To depict the bird's line of travel, the average flight direction was determined by connecting the first and last observation points. These data were mapped using ArcGIS software and the "CogoInput" extension. On the map the length of the arrows varies since it is based on estimated distances between the bird and the observer for the first and last call. The second technique was based on a set of data (collected in most of the surveys) in which the minimum distance and bearing to the observer were recorded. In addition, the observer estimated the direction of travel for each bird. For instance, the observer would determine that the bird was heard at a point approximately 200 m to the southwest of the observer and that, from there, it appeared to be flying due south. These data resulted in the mapping of a vector indicating the direction of travel from one point. On the maps all of these vectors have the same length as repeated calls of a passing bird were only used to estimate direction of travel without recording the estimated distance for repeat calls.

REVIEW OF PUBLISHED RADAR SURVEYS

A review of three published nocturnal radar surveys provides some information on petrel and shearwater occurrence in HAVO. Reynolds et al. (1997) recorded seabird targets at several sites in the park. Radar survey locations within the park included Pali Uli (end of Chain of Craters Road), Mauna Loa (end of Mauna Loa Road), and Kealakomo. Radar data from Kealakomo (630 m) were not included in the results because insects and rain interfered with target identifications during evening surveys. However, Reynolds et al. reported improved visibility at coastal and high elevation locations. Movement rates at Pali Uli were the highest that they detected on the island. At the Pali Uli site, 115 seabird targets were detected in 30 minutes, resulting in a rate of 230 targets per hour. At the Mauna Loa site, 28 seabirds were detected, including one petrel or shearwater sighted visually, resulting in a rate of 18.6 targets per hour. The predominant flight direction at both sites was northeast during these evening surveys.

Day et al. (2003) surveyed one coastal site inside HAVO at Hōlei Sea Arch between 31 May 2001 and 22 June 2002. They recorded a rate of 1.2 targets per hour with birds flying in a predominantly seaward direction during the evening surveys, apparently to go out to feed. They surmised that 100% of targets were NESH, based upon the timing of flight. This assumption was based on the fact that, while radar detections of NESH and HAPE are indistinguishable, visual data from Kauaʻi had indicated that they differ in the timing of movements (Day and Cooper 1995). In that study Hawaiian Petrels were reported to fly inland <60 minutes past sunset, while NESH fly inland >30 minutes past sunset onward. Thus, detections >60 minutes after sunset were assumed to be NESH. However this finding about the differential timing of the two species has been questioned (see discussion and recommendation section).

Day et al. (2004) conducted radar surveys from Kīlauea Visitor Center (1,220 m) in July 2004. In approximately 44 hours of surveys, they detected three targets moving southwest in the morning. At least two of these targets were assumed to be NESH, based upon the timing of movement.

RESULTS

Mauna Loa Radar Surveys

During radar surveys on 10 and 12 September 2002, HAVO RM observers identified 19 targets as HAPE or BSTP, based on speeds of 30 mph and greater, resulting in a rate of four targets per hour. The earliest seabird target was detected at 19:12 h and the latest was detected at 21:59 h, just before the end of the surveys. Of the total targets observed over the two nights of sampling, the highest number of seabird targets, six of the total 19 (31%, or 12 targets per hour), were observed between 21:05 and 21:30 h on both nights. After this time, activity dropped considerably to just one target during the next half hour. It was not possible to visually confirm any targets using night vision goggles. Based upon auditory surveys, some slower flying targets did seem to coincide with vocalizing seabirds. In addition, some targets flying slower than 48 km/h appeared to be seabirds, based upon the size of the echo shown on the radar screen.

Colony Searches

During procellariiform colony searches, three species of rare seabirds were detected at locations in Hawai'i Volcanoes National Park: NESH, BSTP, and HAPE (Table 1).

Table 1. Seabird species documented during seabird colony searches, Hawai'i Volcanoes National Park, 27 June–24 August 2005.

Species	Scientific Name	Hawaiian Name	Status*
Band-rumped Storm-Petrel	<i>Oceanodroma castro</i>	`Ake`ake	T&E candidate
Newell's Shearwater	<i>Puffinus auricularis newelli</i>	`A`o	threatened
Hawaiian Petrel	<i>Pterodroma sandwichensis</i>	`Ua`u	endangered

*U.S. Fish & Wildlife listing

Newell's Shearwater

In summer 2005 we were unable to document nesting by NESH at HAVO, though incidental detections suggest that they may still nest in the park. We visited 13 locations to assess whether NESH were present. At eight of those locations, we conducted night surveys because these sites appeared to have potential nesting habitat or NESH had been reported there in the past (Table 2, Figure 2).

Table 2. Survey effort and detections for Newell's Shearwater (*Puffinus auricularis newelli*) during seabird colony searches, Hawai'i Volcanoes National Park, 2005.

Date	Location	Survey times	Total time (h:min)	Detections
27 Jun 2005	Ka`aha	19:45–05:08	9:23	0
28 Jun 2005	Ka`aha	19:00–22:00	3:00	2 ¹
29 Jun 2005	Ka`aha	18:50–19:42	0:52	0 ²
06 Jul 2005	Kahuku Pit Crater	19:30–21:50	2:20	0
19 Jul 2005	Makaopuhi Crater	19:30–22:00	2:30	0
20 Jul 2005	Nāpau Crater	19:15–22:00	2:45	0
21 Jul 2005	East Rift ³	19:49–23:30	3:41	0
26 Jul 2005	Pu`u Huluhulu	19:20–22:00	2:40	0
02 Aug 2005	`Āpua Point	18:25–23:05	4:40	0
03 Aug 2005	`Āpua Point	18:00–23:45	5:45	0
04 Aug 2005	Halapē	18:00–22:30	4:30	0
05 Aug 2005	Halapē	19:45–22:30	2:45	0

¹due to the distance offshore, identification was tentative; possibly these birds were HAPE.

²a flock of 40 procellariiform seabirds was observed which possibly included NESH; see text below.

³At the junction of the Nāulu and Kalapana trails.

We tentatively identified approximately 40 distant procellariiform seabirds staging offshore at Ka`aha on 29 June 2005. These birds appeared to be congregating offshore at dusk before flying inland to breeding colonies. The flock displayed two types of behavior. The first half of the flock began to circle upward at twilight, climbing higher into the sky before disappearing from view. The second half of the flock remained at the ocean surface until they were no longer visible because of falling darkness. It is possible that the flock contained both Hawaiian Petrels and Newell's Shearwaters but we were unable to visually distinguish species due to the birds' distance offshore.

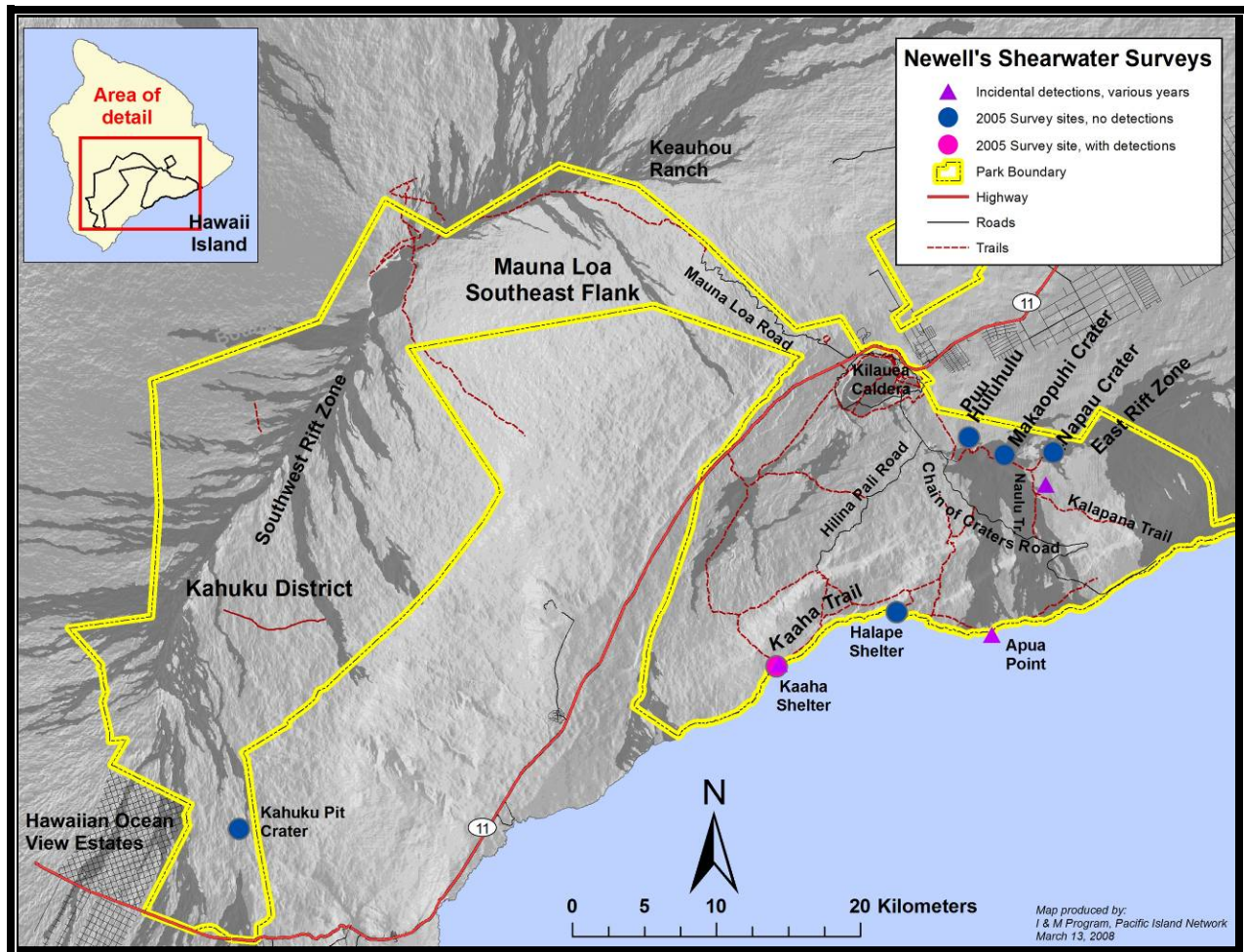


Figure 2. Results of nighttime auditory surveys for Newell's Shearwater (*Puffinus auricularis newelli*) along the coast and at mid-elevations, Hawai'i Volcanoes National Park, conducted in 2005. Also shown are detection sites from incidental observations by national park crews.

We did not detect any NESH over land during three nights of surveys at Ka`aha, an indication that NESH are probably not nesting there. In addition, no evidence of seabird nesting was noted during daytime visual scanning of the cliffs around Ka`aha. Seabird guano was found along the coast toward Kālu`e during shoreline bird surveys in March 2005, but two subsequent visits to the site showed no further evidence of the presence of seabirds.

Newell's Shearwater vocalizations were heard by a park trail worker on two nights in May 2005 at Ka'aha (M. Lane, NPS, pers. comm.), by Hawksbill Turtle Project volunteers on two nights in June 2003 at `Āpua Point, and by Hawksbill Turtle Project volunteers for a week in mid-July 2005 at Keauhou Landing, located between `Āpua Point and Halapē (W. Seitz, pers. comm.). Resource Management vegetation crew workers also heard NESH vocalizations near the junction of the Kalapana and Nāulu trails on 19 and 20 July 2005 (D. Salmo, NPS, pers. comm.).

Wedge-tailed Shearwater

No Wedge-tailed Shearwaters (*Puffinus pacificus*) were observed during the 2005 seabird surveys. However, a carcass was collected on top of cliffs in the vicinity of Ka'aha in June of that year during shoreline bird surveys (Kozar et al. 2007). No WTSH have been reported by Hawaii Volcanoes National Park sea turtle monitors stationed at park beaches throughout the summer and fall months of the last ten years.

Band-rumped Storm-Petrel and Hawaiian Petrel

Nighttime auditory surveys and daytime ground searches were conducted at HAVO to document occurrences of BSTP and HAPE. The main focus was on locating BSTP nests, given that several HAPE nest sites are already documented (Figure 2). Since nesting habitat preferences of BSTP are largely unknown for Hawai'i, most data collected were in the form of nighttime auditory surveys. In 2005, we spent 13 hours searching for BSTP nests at three sites and found one potential nest site (Table 3). This possible nest was found at Kahuku along the Southwest Rift Zone of Mauna Loa. Evidence of nesting included numerous small guano droppings around small openings in a pāhoehoe flow. This site is in the general vicinity of the site where a BSTP wing was found in earlier surveys (Banko et al. 1997).

Table 3. *Band-rumped Storm-Petrel (Oceanodroma castro) nest search results, Hawai'i Volcanoes National Park, 2005.*

Date	Location	Survey hours	Findings
10 August 2005	"Bates" benchmark ¹	4	No nests
17 August 2005	North of Hāpai Mamo ²	6	One possible nest
18 August 2005	Hāpai Mamo Cindercone ²	3	No nests

¹Survey route began at the last hairpin on Mauna Loa Road at 2000 m elevation, past "Bates" benchmark and up to Mauna Loa trail at 2400 m.

²South Kahuku

This is the second possible BSTP nest found in recent years. Another possible nest site was found in 2004 by HAVO RM staff, among boulders on a small peak along a rift in the Southwest Rift Zone. The RM staff observers found eggshell fragments and guano at the site. Confirmation of BSTP occupation of these two sites will require positive species identification which could be accomplished by molecular analysis of the guano and possibly the eggshells (S. Jarvi, University of Hawaii, pers.comm.) or through photographs, visual observations, or bird remains. We attempted to confirm another suspected BSTP nest near three known HAPE colonies on the southeast flank of Mauna Loa (Figure 3), but photographs revealed that the nest was occupied by a HAPE (Figure 4).

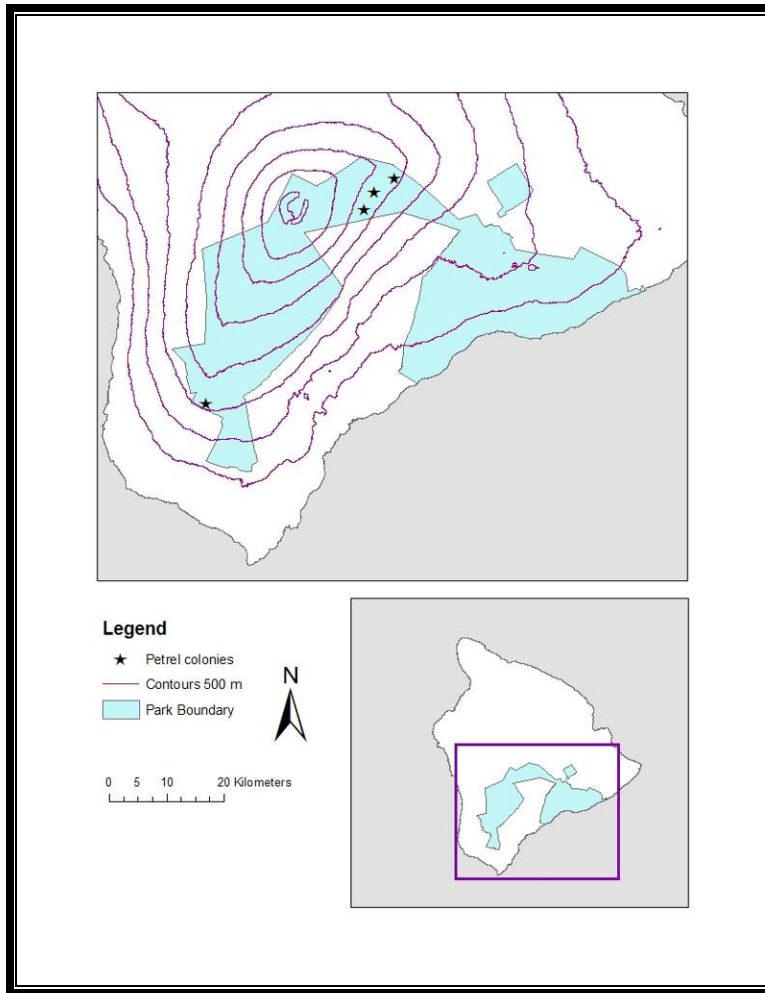


Figure 3. Approximate locations of Hawaiian Petrel (*Pterodroma sandwichensis*) colonies in Hawai'i Volcanoes National Park. To protect nest sites from disturbance, only approximate locations are given; exact locations are archived at the Pacific Island Network and Resources Management offices.



Figure 4. Hawaiian Petrel (*Pterodroma sandwichensis*) at burrow on Mauna Loa, Hawai'i Volcanoes National Park, 23 August 2005.

In addition to ground searches in appropriate habitat, we conducted nighttime auditory surveys in three high elevation locations (sites Southeast 2 and 3 and Hāpai Mamo) in 2005. Table 4 presents detection data for these surveys as well as for previous survey efforts within the park by the Resources Management division of HAVO and the multiagency survey effort organized by the 'Ōla'a-Kīlauea Partnership that took place just outside the national park in 2004. Figures 5 and 6 identify the survey locations.

The earliest BSTP arrived at survey sites on Mauna Loa at 18:40 h, but birds did not begin to consistently arrive until about one hour later. The latest BSTP detected was recorded at 23:22 h, but most surveys ended by 22:00 h when BSTP were still calling; therefore results exclude these data. The peak time period for BSTP activity was between 21:00 and 21:30 h, though activity was high between 20:30 and 22:00 h.

Table 4. Nighttime auditory survey data for Band-rumped Storm-Petrel (BSTP) and Hawaiian Petrel (HAPE); Hawai'i Volcanoes National Park and Keauhou Ranch, 2001, 2004, and 2005.

Location	Date	Time Start	Time End	Hours	Number of BSTP Detections	BSTP Detections per Hour	BSTP Detections per Hour (average)	Number of HAPE Detections	HAPE Detections per Hour	HAPE Detections per Hour (average)
Kahuku A	20 Jul 04	18:00	22:45	4.75	4	0.8	0.8 ¹	0	0.0	0.0 ¹
Kahuku B	22 Jul 04	20:00	21:45	1.75	8	4.6	4.6 ¹	2	1.1	1.1 ¹
Kahuku C	21 Jul 04	20:40	22:10	1.50	14	9.3	9.3 ¹	3	2.0	2.0 ¹
Kahuku D	20 Jul 04	20:00	22:00	2.00	0	0.0	0.0 ¹	1	0.5	0.5 ¹
Kahuku E	19 Jul 04	20:00	22:15	2.25	1	0.4	0.4 ¹	0	0.0	0.0 ¹
Kahuku F	21 Jul 04	19:30	22:00	2.50	2	0.8	0.8 ¹	2	0.8	0.8 ¹
Kahuku G	22 Jul 04	19:30	22:00	2.50	3	1.2	1.2 ¹	2	0.8	0.8 ¹
Kahuku H	22 Sep 04	18:40	20:40	2.00	2	1.0	1.0 ¹	0	0.0	0.0 ¹
Kahuku I	18 Aug 04	19:34	22:00	2.43	4	1.6	1.6 ¹	1	0.4	0.4 ¹
Hāpai Mamo	10 Aug 04	20:43	21:25	0.70	9	12.9	12.9 ¹	4	5.7	5.7 ¹
Hāpai Mamo A	10 Aug 04	19:45	20:20	0.58	3	5.2	3.2	1	1.7	3.0
Hāpai Mamo A	19 Aug 04	19:30	21:22	1.87	2	1.1		9	4.8	
Hāpai Mamo A	18 Aug 05	20:00	22:00	2.00	7	3.5		5	2.5	
Hāpai Mamo B	17 Aug 04	19:38	21:30	1.86	1	0.53	0.53 ¹	17	9.13	9.13 ¹
Keauhou 2	06 Jul 04	20:00	22:00	2.00	14	7.0	6.4	4	2.0	1.0
Keauhou 2	07 Jul 04	20:00	22:00	2.00	15	7.5		0	0.0	
Keauhou 2	08 Jul 04	20:00	22:00	2.00	10	5.0		2	1.0	
Keauhou 4	06 Jul 04	19:30	22:00	2.50	43	17.2	13.9	7	2.8	1.9
Keauhou 4	07 Jul 04	19:30	22:00	2.50	43	17.2		6	2.4	
Keauhou 4	08 Jul 04	20:20	22:00	1.67	12	7.2		1	0.6	
Keauhou 5	06 Jul 04	19:30	22:00	2.50	16	6.4	3.3	1	0.4	0.4
Keauhou 5	07 Jul 04	19:30	22:45	3.25	9	2.8		3	0.9	
Keauhou 5	08 Jul 04	20:00	23:22	3.37	2	0.6		0	0.0	

Location	Date	Time Start	Time End	Hours	Number of BSTP Detections	BSTP Detections per Hour	BSTP Detections per Hour (average)	Number of HAPE Detections	HAPE Detections per Hour	HAPE Detections per Hour (average)
Keauhou A	06 Jul 04	19:30	22:00	2.50	26	10.4	8.7	2	0.8	1.1
Keauhou A	07 Jul 04	19:30	22:00	2.50	21	8.4		1	0.4	
Keauhou A	08 Jul 04	19:30	22:00	2.50	18	7.2		5	2.0	
Southeast 1	09 Jul 01	20:19	21:59	1.67	20	12.0	12.0 ¹	2	1.2	1.2 ¹
Southeast 2	17 Jul 01	20:57	22:05	1.13	8	7.1	7.0	0	0.0	0.8
Southeast 2	25 Aug 04	19:30	21:30	2.00	4	2.0		3	1.5	
Southeast 2	26 Aug 04	19:25	21:35	2.17	12	5.5		3	1.4	
Southeast 2	23 Aug 05	19:20	22:00	2.67	17	6.4		1	0.4	
Southeast 2	24 Aug 05	19:15	21:10	1.92	27	14.1		1	0.5	
Southeast 3	11 Aug 05	20:00	21:55	1.92	29	15.1	15.1 ¹	4	2.1	15.1 ¹
Red Hill	09 Jan 04	20:47	21:42	1.08	0	0	0 ¹	0	0	0 ¹

Location	Date	Time Start	Time End	Hours	Number of BSTP Detections	BSTP Detections per Hour	BSTP Detections per Hour (average)	Number of HAPE Detections	HAPE Detections per Hour	HAPE Detections per Hour (average)
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¹based only on one night of observation

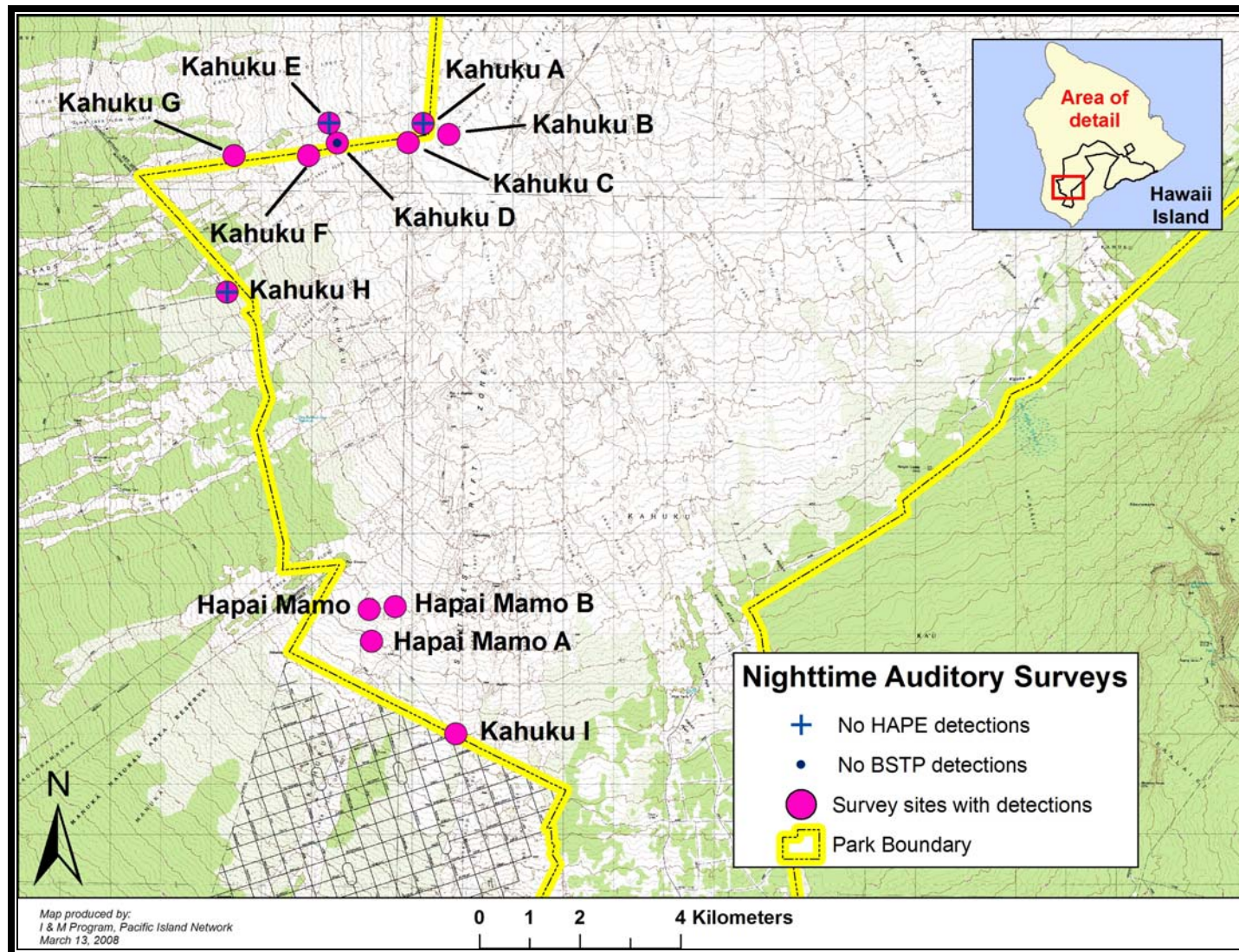


Figure 5. Nighttime auditory survey locations for procellariiform seabirds in Kahuku, Hawai'i Volcanoes National Park, conducted in 2004 and 2005. Species recorded included Band-rumped Storm-Petrel (BSTP) and Hawaiian Petrel (HAPE). Note that survey effort varied between sites.

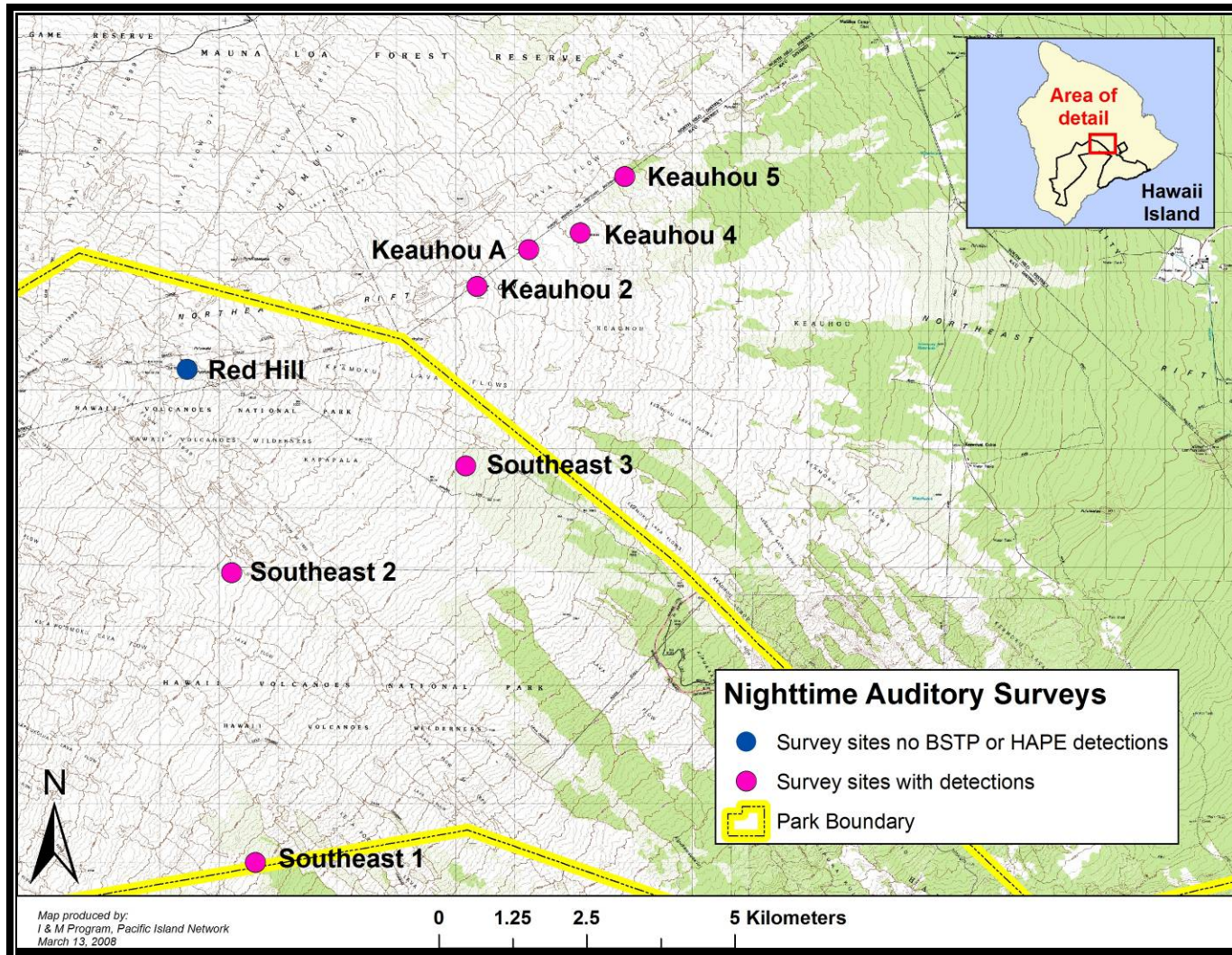


Figure 6. Nighttime auditory survey locations for procellariiform seabirds on the southeast flank of Mauna Loa, Hawai'i Volcanoes National Park and Keauhou Ranch for surveys conducted in 2001, 2004 and 2005. Species recorded included Band-rumped Storm-Petrel (BSTP) and Hawaiian Petrel (HAPE). Note that survey effort varied between sites.

Band-rumped Storm-Petrel and Hawaiian Petrel Flightlines

Surveys Within the Park

We mapped direction of travel for BSTP and HAPE detected during nighttime auditory surveys between 2001 and 2005.

Observations at the Southeast 2 site show one common line of travel for BSTP to and from the north/northeast (Figure 7). This line of flight probably represents birds leaving nesting colonies in the evening to return to sea and indicates that nesting areas may be located north/northeast of this location.

Evening auditory surveys on Mauna Loa at the Southeast 3 site (Figure 8) show the most common line of travel to be toward the northeast, possibly toward Keauhou. In fact, many BSTP that were documented flying along the Keauhou boundary between Kūlani and HAVO (Figure 12) flew southwest, toward HAVO. Therefore, BSTP may be nesting at high elevations between the two locations, possibly along the national park's Keauhou boundary.

Although BSTP were numerous along the Kapāpala boundary fence at the Southeast 1 site (Figure 9), we were only able to map a small portion of the individuals detected. Four of the seven BSTP individuals mapped flew upslope in a north or northwesterly direction, possibly flying toward nests at higher elevations. One flew towards the southwest from our survey location, possibly toward marine feeding grounds off South Point. Another flew toward the northeast, possibly returning to its nest following a fishing trip. The seventh appeared to fly due east, possibly to nesting areas on other parts of the mountain.

BSTP flying along the western boundary in the Kahuku unit showed a distinct pattern of flying upslope beyond the uppermost survey site near the boundary corner (Figure 10). These birds may be flying to high elevation cinder cones. Flight paths at Hāpai Mamo (Figure 11) were mainly directed up- and downslope to and from the northeast, indicating that BSTP may nest higher up along the Southwest Rift Zone.

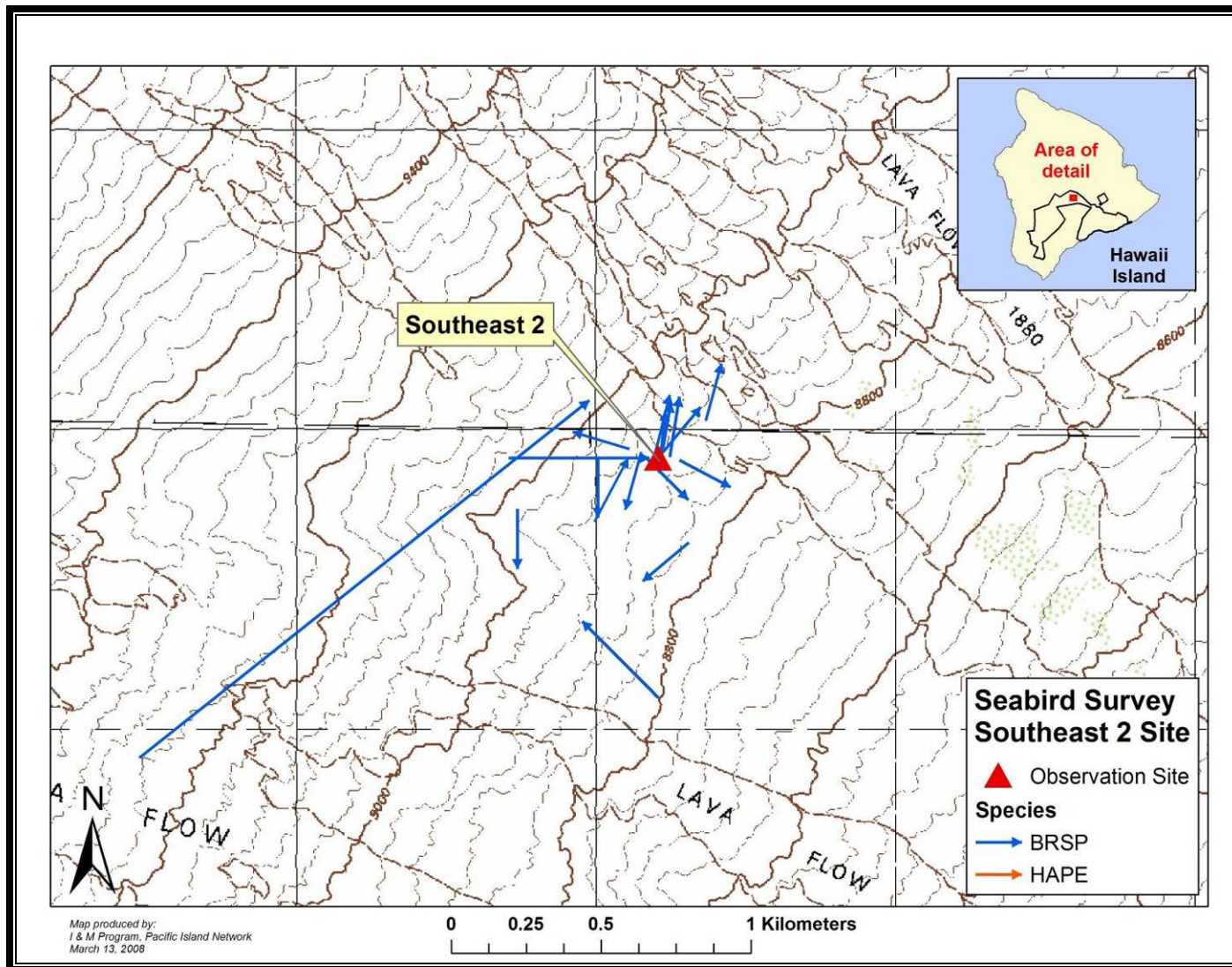


Figure 7. Map of flightlines based on nighttime auditory surveys at the Southeast 2 site, on the southeast flank of Mauna Loa. The surveys were conducted in July 2001, August 2004, and August 2005. BSTP = Band-rumped Storm-Petrel. Note that HAPE (Hawaiian Petrel) were observed at this site, but flight directions could not be determined.

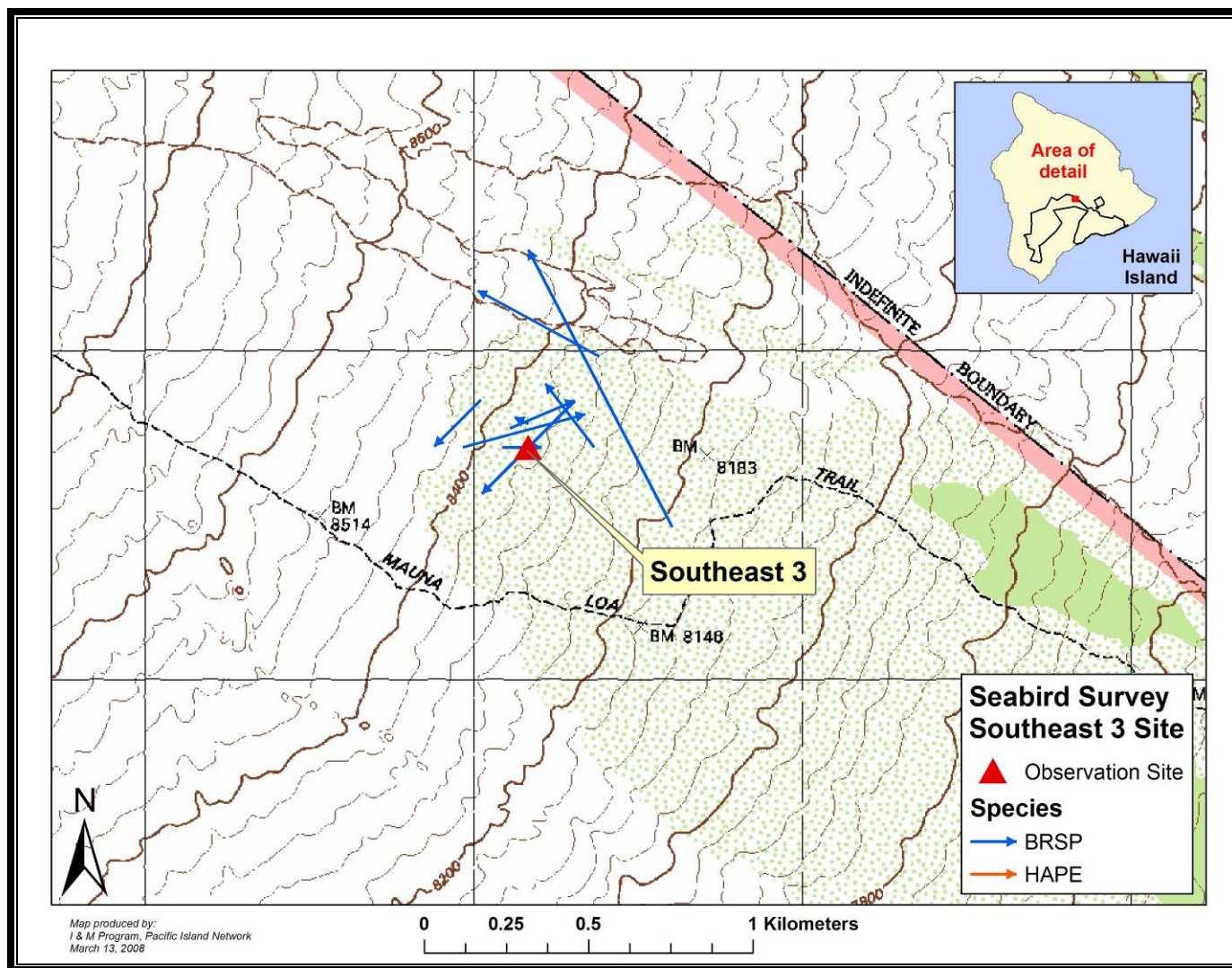


Figure 8. Map of flightlines based on nighttime auditory surveys at the Southeast 3 site, on the southeast flank of Mauna Loa. The survey was conducted in August 2005. BSTP = Band-rumped Storm-Petrel. Note that HAPE (Hawaiian Petrel) were observed at this site, but flight directions could not be determined.

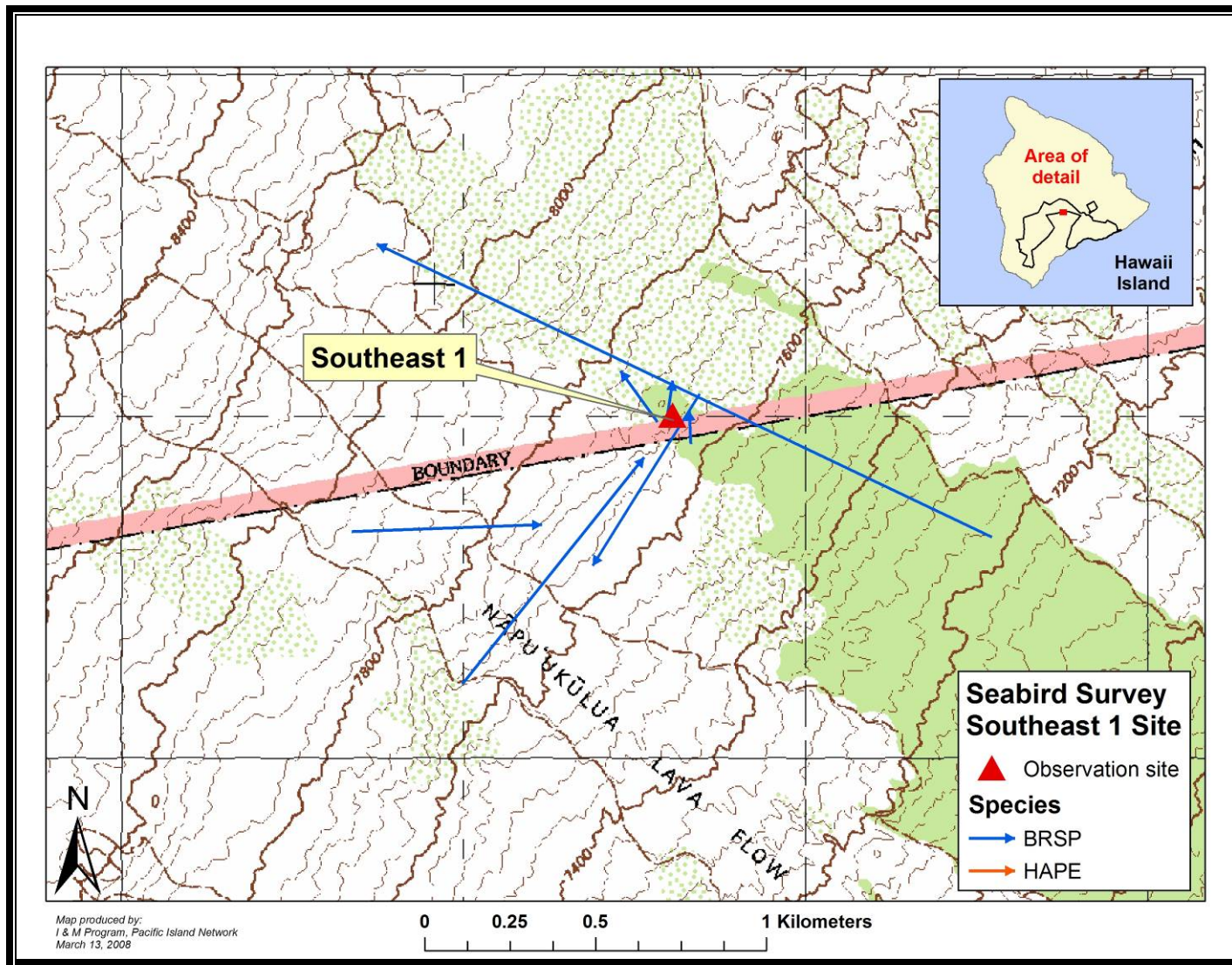


Figure 9. Map of flightlines based on nighttime auditory surveys at the Southeast 1 site located along the HAVO/Kapāpala fence line on the southeast flank of Mauna Loa. The survey was conducted in July 2001. BSTP = Band-rumped Storm-Petrel. Note that HAPE (Hawaiian Petrel) were observed at this site, but flight directions could not be determined.

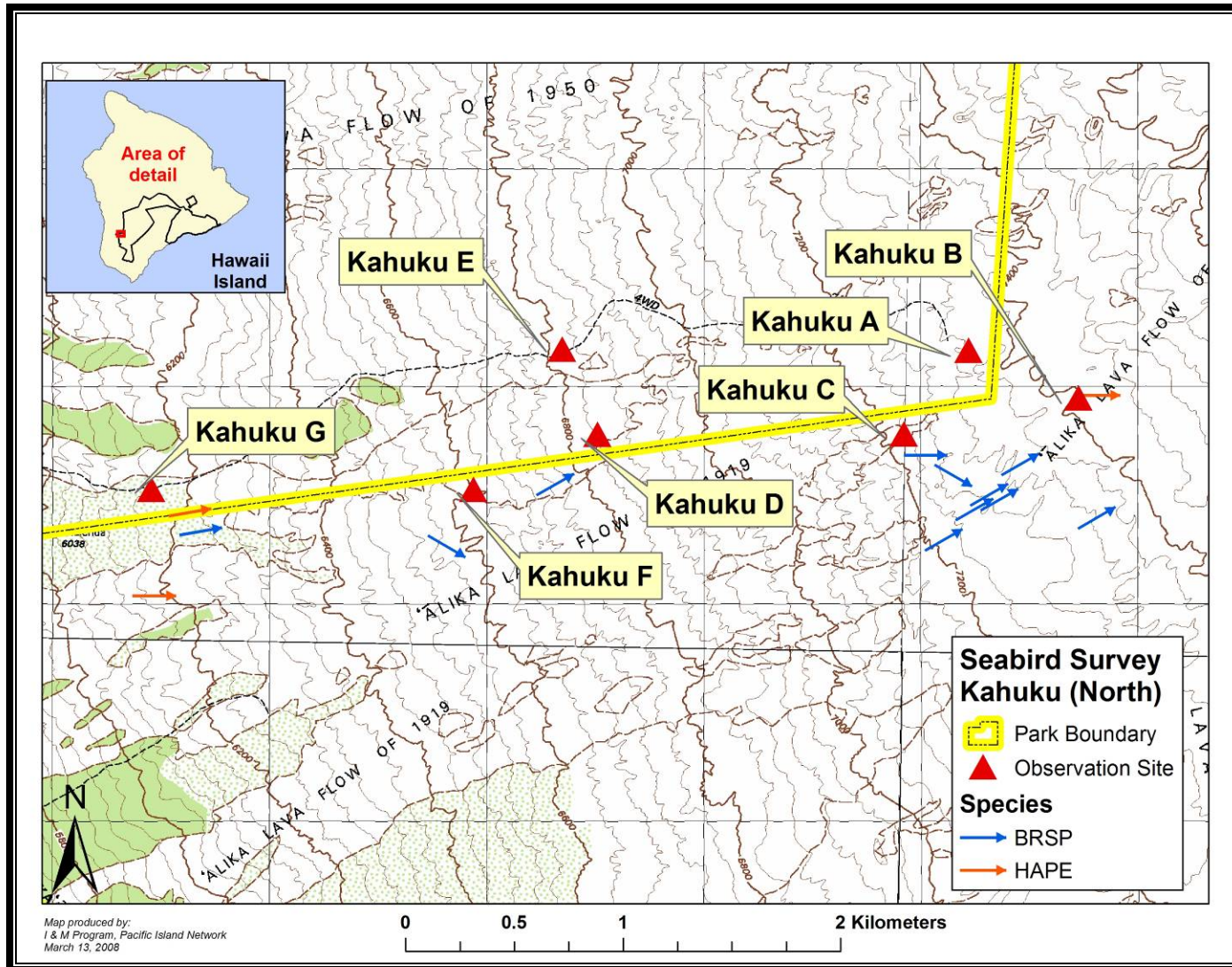


Figure 10. Map of flightlines based on nighttime auditory surveys on the western Kahuku boundary, northwest flank of Mauna Loa. Surveys were conducted in July of 2004. BSTP = Band-rumped Storm-Petrel, HAPE = Hawaiian Petrel.

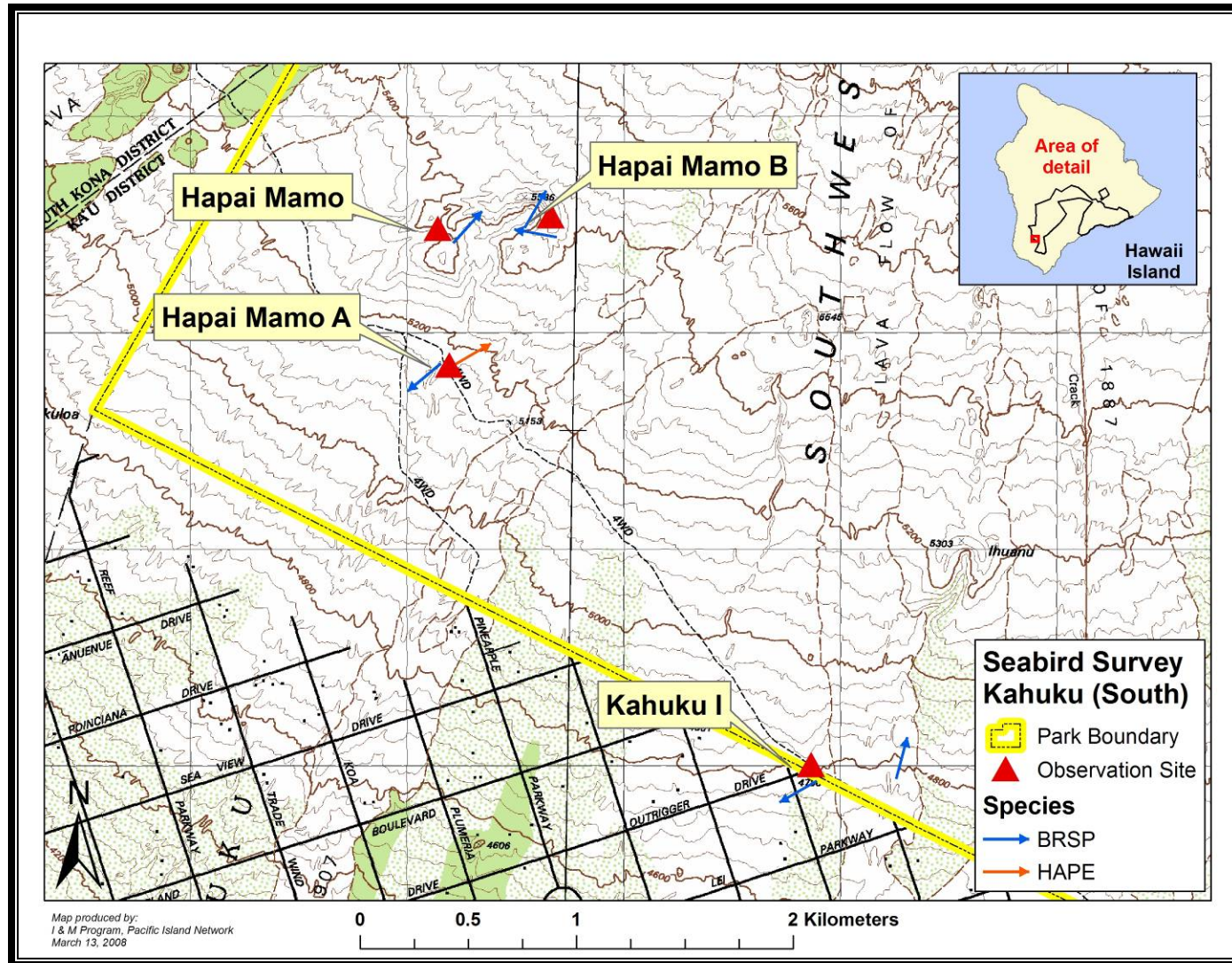


Figure 11. Map of flightlines based on nighttime auditory surveys near Hāpai Mamo along the Southwest Rift Zone of Mauna Loa. Surveys were conducted in August 2004 and August 2005. BSTP = Band-rumped Storm-Petrel, HAPE = Hawaiian Petrel.

Surveys Outside the Park

For these 2004 surveys, the highest number of montane seabird detections occurred at the Keauhou 4 site with 98 potential BSTP, 14 HAPE, and six birds of unknown species in three nights. The first detections occurred around 20:30 h (20:19, 20:27, and 20:29 h) with activity peaking between 21:30 and 22:00 h, though birds were still detected after surveys ended at 22:00 h. Most birds at this location appeared to be flying upslope in a west/northwest direction. It is possible that they were flying in the direction of the complex of cinder cones on state land. The deviations from this general pattern included a few birds that flew upslope to the west and southwest and downslope to the northeast and southeast. Only one bird flew downslope during the first night of observations but this number increased to fifteen during the second night of observations. Some birds appeared to circle, and their flight direction was difficult to determine. One visual confirmation of a HAPE indicated that this bird was flying at about the level of the 10-meter-high pu'u upon which the observers sat. Another silent individual flew within five meters of the observers' heads.

The second most active location was the Keauhou A site where observers detected 65 potential BSTP, eight HAPE, and six birds of unknown species over three nights. The first bird detections occurred slightly later than at the Keauhou 4 site, at 20:30, 20:37, and 20:43 h. Most birds flying upslope (22) appeared to be flying to the northwest, in the direction of cinder cones near Keauhou 3. Similar numbers flew downslope (23) with a few birds flying cross-slope to the south (three) and north (two). Some birds were also headed seaward. Birds appeared to be flying up the mountain in strings, and a lot of birds were detected between Keauhou A and Keauhou 4. This team had visual confirmations of two birds, one of each species. One appeared to be a BSTP based upon its characteristic bat-like flight and smaller size. This bird was heard using the "ti-ti" call, contributing to the determination that this may be a BSTP vocalization. One silently flying HAPE was also visually identified based on its larger size and less erratic flight habit. Both birds appeared to be flying five to ten meters off the ground. At this location, similar numbers of birds flew upslope (25) and downslope (20). Four birds flew across the slope to the northwest (three) or southeast (one) and 12 birds flew in an unknown direction. Averaged over the three nights, the time period between 21:30 and 22:00 h was the most active, except on 07 July when the time period between 21:00 and 21:29 h had one more detection than between 21:30 and 22:00 h.

The second lowest number of detections was at Keauhou 2, the site at the highest elevation. Detections included 39 potential BSTP and six HAPE, with six visual confirmations: five possible BSTP and one pair of HAPE. For four of the five potential BSTP visual sightings, high-pitched "ti-ti" calls were heard along with visual confirmations of bat-like erratic flight, approximately 4.5 to six meters off the ground. The pair of HAPE seen flew silently and straighter than the BSTP. Most birds were flying in the direction of Keauhou 1 (southwest) but some flew toward the north/northwest. The observers noted a lava channel running northeast-southwest (parallel to the boundary line), adjacent to their survey site and surmised that birds might be following this landmark up the mountain. Detections of HAPE were infrequent but during the first night of surveys (06 July), one HAPE called from an apparently stationary position at 200 m north of the survey site from 20:30 to 21:50 h, suggesting potential display behavior. The most active time period during the first two nights was from 21:00 to 21:29 h. On the third night of surveys, most birds were detected between 21:30 and 22:00 h. Surveyors could not discern flight directions for most of the birds detected.

The least active survey site was Keauhou 5, the lowest elevation site. A total of 31 passes of montane seabirds were detected, including 27 potential BSTP and four HAPE. Most birds called from the north side of the observers and were heading downslope to the north/northeast, flying parallel to the fence alignment and apparently avoiding the pāhoehoe kipuka within which the survey site was located. It was not possible to ascertain flight direction for most birds because most only called once or twice. Time of first detections ranged from 20:24 to 21:05 h with the most active time period between 21:30 and 22:00 h on 06 July and between 21:00 and 21:30 h on 07 July. Only two passes were detected on 08 July. All parties noted that calling did not begin until approximately one hour after the survey start (20:30 h) and continued beyond the end of surveying (22:00 h).

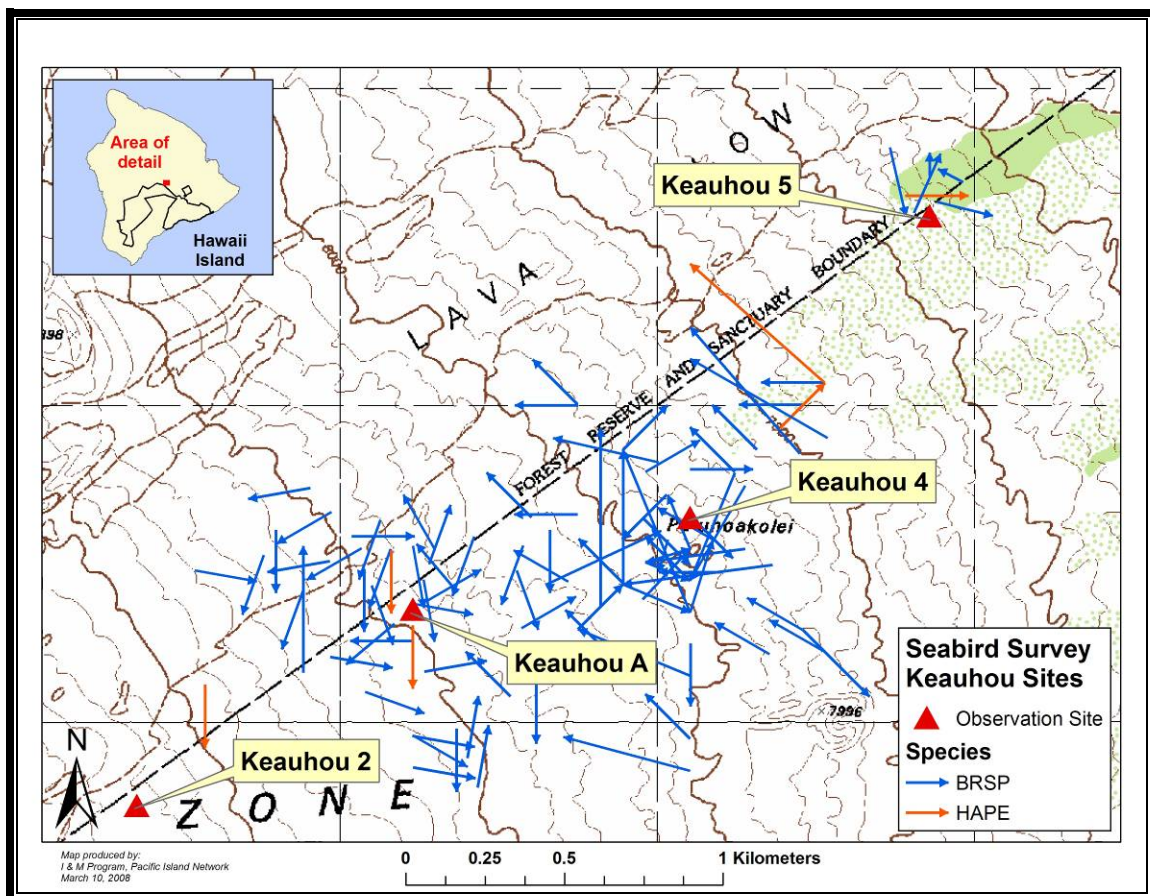


Figure 12. Map of flightlines based on nighttime auditory surveys on Keauhou Ranch, Mauna Loa. BSTP = Band-rumped Storm-Petrel, HAPE = Hawaiian Petrel.

DISCUSSION AND RECOMMENDATIONS

The purpose of this study was to provide baseline data about procellariiform seabird species at HAVO by summarizing the results of previously published as well as unpublished surveys and by surveying procellariiform seabird diversity and identifying flight corridors and colony sites within park boundaries. Our observations establish that NESH and BSTP still occur inside the park and indicate general areas that are likely nesting habitats. Although we failed to locate exact nesting sites, the data we gathered may aid future searches for NESH and BSTP nesting colonies.

Though we did not find NESH nesting sites during our surveys, this is likely due to insufficient survey effort and the fact that part of our search effort was conducted in coastal areas. However, our first search priority was to confirm incidental reports of NESH calls in order to document NESH occurrence within HAVO. Therefore, some of the coastal areas we visited were suboptimal habitat judging from the habitats of documented colonies outside HAVO and on other Hawaiian islands. Numerous incidental auditory detections by park staff suggest that NESH still occur in the park and may be prospecting for nest sites at low to mid elevations. Cat scat has been found at many locations in the park (HAVO RM unpub. data) from low to high elevations; it is likely that in addition to mongooses, these predators are preventing successful nesting. It may be possible for NESH to re-colonize lowland areas in the park if measures such as predator control and restoration of native vegetation were implemented. Incidental observations by park staff suggest that NESH do nest in the forest of the Kīlauea East Rift Zone, at 700 to 900 m. However, finding them in the uluhe fern thickets would require a more concerted and sustained effort than was possible in this inventory. Helicopter transport would facilitate access to the area and trained search dogs might allow finding nest sites within this densely vegetated habitat. One must consider, however, that trampling uluhe fern cover may pose a threat to nesting seabirds by facilitating access for predators such as cats. Colonies should first be located using less invasive means such as radar, night vision, and auditory surveys. Predator control should be conducted during and following such efforts. As a further precaution, searches with dogs should not occur until after the breeding season.

Repeated consecutive nighttime radar, night vision, or auditory surveys will be required to pinpoint nesting by this rare seabird. During surveys in the Puna District adjacent to HAVO, Reynolds and Ritchotte (1997) visited one site 11 times for 275 survey hours in 1993, with a mean detection rate of one detection per hour in order to document nesting. Nest attendance data from surveys at other islands may provide some information on the timing of the most regular and frequent travel to the nests and thus may improve the chances of detecting birds at very small colonies. Such data are available for the Kīlauea Point National Wildlife Refuge on Kauai (H. Freifeld, US Fish and Wildlife Service, pers.comm.). However, timing of bird travel has been found to vary between colonies on different islands (D. Ainley, H.T. Harvey & Associates, pers.comm.) and a wide window should be applied in future observations to allow for these differences. Given the time and cost involved in prolonged monitoring, it would be worthwhile to investigate the use of remote auditory recording equipment at promising sites to find out more about seasonal detection probabilities.

We were able to identify potential nesting sites for BSTP in the park that could be confirmed with future monitoring. The numerous detections of transiting BSTP and possible nest sites

suggest that they do breed on Mauna Loa. The two potential nests are in the vicinity of the nest reported by Banko et al. (1991). It is surprising that BSTP nests have not been found at this location and in other areas of Mauna Loa. It is possible that nesting birds have retreated to higher elevations in recent decades due to increasing pressure from introduced predators, such as mongooses whose upper elevation limit is around 2,100 m (HAVO RM unpubl. data). Alternatively, observers may have overlooked nests or did not search in inaccessible areas where nests may be located. This is possible since BSTP nest site selection preferences have not yet been described. In addition, nests of BSTP may be more inconspicuous, and therefore more difficult to find, than nests of the larger HAPE. Additionally, it is possible that BSTP have better nest hygiene, leave less guano outside of nests, or are otherwise less disruptive to the substrate because of their smaller size. Based on records of BSTP carcasses found among HAPE colonies, we previously thought that they were nesting among HAPE, though we were unable to confirm this through photographs or by measuring footprints at nest entrances.

The maps of flightlines will be useful for future efforts in locating BSTP colonies. The data show that most BSTP detected were flying either up- or downslope, indicating that their colonies are at higher elevations than our survey areas. Before mapping flightlines in the future, the accuracy of the two methods of data collection for flightlines should be investigated. In the first method, each detection was mapped as a point, then the points were connected to determine the average direction of flight. In the second technique, observers estimated the overall direction of travel of each bird, resulting in the mapping of a vector rather than a series of points. We suggest that this second method depicts the line of travel more accurately, because error in distance measurements are compounded when more than one distance is estimated.

No previous radar surveys have been conducted specifically for BSTP. Therefore, the exact signature this species leaves on the radar screen is not known. Though speed and behavior are well established for HAPE and NESH transiting to colonies, it is possible that the smaller BSTP, which have more erratic flight and fly slower, may not leave as clear a signature as the other two species. There is a need to distinguish BSTP from HAPE where both occur together. Using the 48 km/h flight speed cutoff established for the larger seabirds may have resulted in a failure to count BSTP. In addition, HAPE at high elevations may act differently than those transiting to colonies at low elevations, where standards of speed, behavior, and timing were developed. Within colonies, pre-breeding HAPE follow curved flight paths while conducting aerial breeding displays (personal observation). Displaying birds may fly slower than the 48 km/h cutoff established for transiting birds. In addition, petrels fly much lower to the ground at higher elevations within the breeding colony and therefore may disappear periodically behind high points on the landscape. For example, HAPE have been observed flying lower than one meter above ground level (personal observation) while banking around bushes in their path. Because of these different flight patterns at high elevations, it may be difficult to distinguish displaying HAPE and BSTP from bats or Barn Owls, both of which occur at higher elevations (personal observation). In addition, it is difficult to find the perfect radar placement when the radar unit must be flown in. Using truck-mounted radar, the operator is able to review ground clutter patterns (landscape features that prevent the radar from detecting the birds) before making a final site selection. When the radar unit is placed by helicopter, it can be placed only once, and the operator does not have the opportunity to minimize ground clutter. Because of these

incongruities between bird biology and logistics, radar may not be an appropriate tool at higher elevations, at least where displaying birds confound flight patterns.

When interpreting the previous radar survey data, it appears that Reynolds et al. (1997) detected significantly more seabird targets at their coastal location at Pali Uli (3.8 targets/hour) as compared to observations by Day et al. (2003) at Hōlei Sea Arch (1.2 targets/hour). Day et al. (2003) did not detect any change in population size from 1995 to 2002 that would explain this difference between these two surveys. One explanation may be that the survey by Reynolds et al. lasted only 30 minutes as compared to the three hours of surveys conducted by Day et al. If this 30-minute survey were conducted during the peak of flight, estimates would be higher compared to the rate observed by Day et al., which would span more time when fewer birds are present. Other factors could also account for this difference; counts can be highly variable between nights because the detection probability of nocturnal petrel species varies seasonally, diurnally and with moon phase (Telfer et al. 1987). Day et al. saw birds flying towards the ocean in the evening, suggesting that these were adult birds returning to sea to forage after darkness. Reynolds et al. noted birds flying northeast in the evening, a path that might take these birds into the East Rift Zone of Mauna Loa, outside park boundaries.

For future radar surveys, extending the radar survey hours beyond 22:00 hrs should be considered. While the results of the HAVO-RM radar surveys reported here show a significant drop-off in bird detections after 21:30 hrs, the two nights of surveying were likely not sufficient to determine that these pulses and timing weren't anomalous. Radar surveys along the roads at Kahuku might be a valuable tool for detecting flight corridors and locating BSTP colonies if located outside HAPE display areas. In conjunction with radar surveys, observers should confirm BSTP radar detections using night vision goggles in order to establish guidelines for flight speeds and patterns. Additionally, the TrailMaster® camera could be used to document BSTP at suspected nest sites. We recommend that those looking for BSTP also search at higher elevations than we did for this survey, above 2,400 m, and along the Southwest Rift Zone of Mauna Loa.

Though we did not specifically target WTSH while surveying for nocturnal Procellariiformes, we believe that we would have detected this species during coastal surveys were they present. It is possible that seabird guano seen near Kalue during shoreline bird surveys in March 2005 was deposited there by prospecting Wedge-tailed Shearwaters. Nesting WTSH would undoubtedly have been detected after more than a decade of constant presence of HAVO sea turtle crews at coastal sites from summer to fall. The distinctive and repeated calls would make them easy to identify. It is probable that WTSH do not nest at HAVO because the young lava substrate makes it impossible for this species to dig its nest burrows. If WTSH did attempt to nest, it is likely that they would be quickly killed by mongooses and feral cats which are especially common at low elevation sites. It appears that WTSH are still attempting to nest on the western side of the island; burrows were detected at Kaloko- Honokōhau National Historical Park in November of 2001 by Ducks Unlimited staff. The burrows were unoccupied and appeared disturbed by rats or mongooses (K. Uyehara, pers. comm.). The burrows were later destroyed by a storm surge and no new burrows have been documented in the park since.

To encourage incidental sightings of seabirds by HAVO field staff working on various projects, employees should receive training on identification of seabird vocalizations. Additionally, all

Hawksbill Turtle Project volunteers should receive the training as they enter the project. A training module and field data forms for future seabird sightings or auditory observations were developed and archived with HAVO RM staff as part of this inventory project.

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